EXECUTIVE SUMMARY

FOR THE

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

OF

DARMSTADT MILITARY COMMUNITY

UNITED STATES ARMY

PREPARED FOR

DEPARTMENT OF THE ARMY
EUROPE DIVISION, CORPS OF ENGINEERS
Contract No. DACA-90-82-C-0187

PREPARED BY

KLING-LINDQUIST, INC., ENGINEERS
2301 CHESTNUT STREET
PHILADELPHIA, PENNSYLVANIA 19103
K/L No. 82-1889-00

ROBERT M. HOUSTON, GmbH
FRANKFURT/MAIN GERMANY

APRIL 1984
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DEPARTMENT OF THE ARMY
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1.0 INTRODUCTION

1.1 General

This summarizes the results of an Energy Engineering Analysis Program (EEAP) of the Darmstadt Military Community. It was conducted by Kling-Lindquist Engineers, Inc. (K/L) for the Department of the Army, Europe Division of the Corps of Engineers under Contract No. DACA-90-82-C-0187. Kling-Lindquist, Inc., employed the services of Robert M. Houston GmbH (RMH), Frankfurt, Germany, to assist in the field survey, cost estimating and other phases of the work requiring local knowledge.

1.2 Project Objective

The objective of this project was to identify cost effective means by which energy consumption at the Military Community can be reduced in accordance with the goals and objectives set forth in the Army Facilities Energy Plan (AFEP). This plan has set a goal for FY 1985 to reduce energy consumption by 20% from the total energy consumption of FY 75.

1.3 Scope of Services Summary - Increments of Work

The Scope of Services for this EEAP required that analyses and investigations be performed on the facilities' energy consuming systems in the Darmstadt Military Community. These investigations and analyses are catagorized into Increments of Work based on the types of energy consuming systems. The Increments of Work included in this contract are as follows:

- Increment "A" - Energy Conservation Investigations, Analyses and Recommendations for Facilities and Processes.
- Increment "B" - Energy Conservation Investigations of Utilities and Energy Distribution Systems, Energy Monitoring and Control Systems (EMCS), Existing Energy Plants
- Increment "F" - Facility Engineer Energy Conservation Measures
- Increment "G" - Projects which do not qualify for ECIP Funding in other increments of work but are viable energy saving projects

1.4 MILCOM Installations Included in EEAP

This EEAP was performed for energy consuming facilities in GY Area installations in the Darmstadt Military Community as follows:

GY NUMBER	CODE	GY NAME
014	GAF	Griesheim Airfield
037	MAP	Muenster Ammo Depot
043	WAA	Walldorf Ammo Area
069	BK	Babenhausen Kaserne
100	CFK	Cambrai Fritsch Kaserne
143	ELK	Ernst Ludwig Kaserne
178	LVFH	Lincoln Village Family Housing
313	NHQA	Nathan Hale QM Area
377	KB	Kelley Barracks
409	MRRS	Melibokus Radio Relay Station
423	GMF	Griesheim Missile Facility
591	ETF	Egelsbach Transmitter Facility
725	BFH	Babenhausen Family Housing
806	JVFH	Jefferson Village Family Housing
807	SBVFH	St. Barbara Village Family Housing
908	DCC	Darmstadt Career Center
977	MSAR	Messel Small Arms Range
*391	BALSC	Bensheim Auerback L S Camp
*454	ORMP	Ober Ramstadt Maintenance Plant
**718	LBTC	Leeheim Bridge Training Center

* Deleted from Study
** No energy use

1.5 Project Execution

The engineering services for this project were accomplished in three phases as follows:

- Phase I - Data Gathering and Facilities Survey. Personnel of Kling-Lindquist Engineers, Inc., Philadelphia, Penna., and Robert M. Houston, GmbH Frankfurt, Germany, conducted surveys of existing facilities and heating plants with respect to their use, construction and energy consuming systems. Data was also obtained from available Community records which included past energy consumption and cost reports, facility lists, and energy conservation projects completed and planned (funded) by the Community. A "kick-off" meeting was held with the Community prior to the start

of the survey and an "exit interview" was conducted at the completion of the survey. The data collected was compiled and submitted to the Corps of Engineers and the Community at the end of Phase I. A follow-up presentation took place at the Community to highlight the information gathered and to preview the project tasks and work plan for for the subsequent phases of work.

- Phase II - This phase consisted of analysis of data, computer modeling of selected facilities listed in Annex "B" of the Statement of Services (SOS), verification of energy calculations against historical records for each GY area, identification of energy conservation opportunities (ECO) with high Savings to Investment Ratios (SIR), feasibility and economic evaluation of selected ECO's and the preparation of the front pages of the DD Form 1391. Preparation of the Energy Report presenting the analysis results and recommendations for the entire Community wide study was submitted at the conclusion of Phase II.

  A follow up presentation was made to the Community to highlight the results of the Phase II work. Topics covered included calculation methodology, discussion of the existing energy situation, Energy Conservation Opportunities (ECOs) analyzed, proposed grouping of the ECOs into projects, and impact of the ECOs being proposed on the energy consumption for the Communities.

  A meeting with the Community took place after the presentation to receive Community direction regarding packaging of the ECOs into projects.

- Phase III - Preparation of project documents which include DA-Form 4283:S and/or completed DD Form 1391 including Project Development Brochures Part 1 (PDB-I), and submittal of the Executive Summary for the project in accordance with the Scope of Services outline.

1.6 Energy Units

The Community consumes energy in various forms. Standard Energy Conservation Investment Program (ECIP) approved conversion factors were used to convert the different energy source values into common units as follows:

Electricity	-	11,600 Btu/Kilowatt Hour
Distillate Fuel Oil (No. 2)	-	138,700 Btu/Gallon (US)
Residual Fuel Oil (No. 6)	-	145,000 Btu/Gallon (US)
Coal	-	27,990,000 Btu/Metric Ton (2,200 Lbs.)

2.0 EXISTING ENERGY SITUATION

2.1 Baseline Energy Consumption (FY 75)

Energy consumed by the Community in FY 75 represents the "Baseline Consumption". The Army Facilities Energy Plan has set a goal to reduce, by FY 85, energy consumption by 20% below the "Baseline Consumption".

FY 75 energy consumption was derived from recorded data obtained from the Darmstadt Military Community and is as follows:

ENERGY SOURCE	CONSUMPTION MILLION BTU	PERCENT OF TOTAL	COST DOLLARS	PERCENT OF TOTAL
Electricity	259,478	29	$1,006,594	37
Distillate Fuel Oil (No.2)	357,017	40	1,209,793	44
Residual Fuel Oil (No.6)	37,912	4	84,022	3
Coal	217,621	25	279,666	10
Gas	18,173	2	145,129	6
Total	890,201	100	$2,725,204	100

2.2 Source Energy Consumption (FY 82)

Energy consumed by the Community in FY 82 represents the "Source Consumption" for this EEAP Study. Energy records for FY 82 were the most recent and complete fiscal year data available for the EEAP. This consumption was designated as the "Source Consumption" since it serves as the reference point for evaluating current compliance with the Army Facilities Energy Plan and also to verify the accuracy of the energy model to be developed for the Community. This energy model will then be used in evaluating Energy Conservation Opportunities.

The energy consumption data for FY 1982 was derived from recorded data obtained from the Darmstadt Military Community and is as follows:

ENERGY SOURCE	CONSUMPTION MILLION BTU	PERCENT OF TOTAL	COST DOLLARS	PERCENT OF TOTAL
Electricity	319,634	36	$1,928,829	30
Distillate Fuel Oil (No.2)	340,058	38	3,407,939	53
Residual Fuel Oil (No.6)	37,295	4	225,420	4
Coal	181,487	20	689,981	11
Gas	14,026	2	112,221	2
Total	892,500	100	$6,364,400	100

2.3 Present Compliance with AFEP

A comparison of the FY 1975 to FY 1982 consumption records indicates that FY 82 energy consumption by the Community had changed from FY 75 as follows:

ENERGY SOURCE	PERCENT CHANGE
Electricity	+ 23
Distillate Fuel Oil (No.2)	- 5
Residual Fuel Oil (No.6)	+ 1
Coal	- 16
Gas	- 23
Change	+ 0.4% (Increase)

2.4 Review of Past Consumption

Energy consumption obtained from Community records is summarized by GY area for FY 75 and FY 82 as follows:

		FY 75 CONSUMPTION			FY 82 CONSUMPTION		
GY NO.	GY NAME	MILLION BTU	%	BTU PER SF**	MILLION BTU	%	BTU PER SF**
014	GAF	63,170	7.0	189,760	65,507	7.3	196,780
037	MAD	33,616	3.7	163,681	39,202	4.4	190,880
043	WAA	-	-	-	290	0	2,196,970
069*	BK	184,410	20.7	165,551	185,935	20.8	166,925
100	CFK	186,178	20.9	204,434	149,385	16.7	164,035
143	ELK	57,550	6.4	141,549	60,382	6.8	148,514
178	LVFH	179,287	20.1	143,906	177,787	19.9	142,702
313	NHQA	37,024	4.2	95,034	38,998	4.4	100,101
377	KB	63,332	7.1	157,375	70,122	7.8	174,247
409	MRRS	3,619	0.4	1,117,665	3,506	0.4	1,082,767
423	GMF	10,496	1.2	552,741	12,638	1.4	665,543
591	ETF	6,515	0.7	1,022,924	14,151	1.6	2,221,856
806	JVFH	39,326	4.4	110,967	46,907	5.3	132,361
807	SBVFH	14,515	1.6	174,784	16,136	1.8	194,304
908	DCC	10,811	1.2	140,191	11,174	1.3	144,898
977	MSAR	361	0	120,333	380	0	126,667
		890,201	100	160,293 (Avg.)	892,500	100	160,707 (Avg.)

* GY 725 included with GY 069

** Based on total MILCOM Facility Area of 5,553,387 S.F.

Several comments can be made with respect to this data.

- In terms of total energy the three largest energy users are GY areas 069/725, 100, 178 which contain barracks and family housing.

- In terms of total energy per square foot, the largest energy users are GY Areas 043, 409, 423, 591 which have small facility areas. GY 043 (Walldorf Ammo Area) has extensive outdoor lighting. GY Areas 409 (Melibokus), 423 (Griesheim Missile), and 591 (Egelsbach) all have extensive electronic communication equipment.

This same information is presented graphically in Appendix Figures A-1 and A-2. In addition, the consumption by energy type is also presented graphically in Appendix Figures A-3 (coal), A-4 (fuel oil) and A-5 (electricity). Comments relating to those Figures are as follows:

- Coal - There was a large reduction at GY 069/725 between FY 75 and FY 82. This resulted from the consolidation of individual Facility coal heating plants into the new central plant in Facility 5557. Energy was also reduced with the installation of weather responsive controls and thermostatic radiator valves.

- Fuel Oil - The increase at GY 069/725 (Babenhausen) resulted from the replacement of coal heating plants in Facilities with oil heating plants. The large decrease at GY 100 (Cambrai Fritsch) has resulted primarily from energy conservation measures implemented by the Community such as weather responsive controls, thermostatic radiator valves, and new thermal windows.

- Electricity - Consumption of electricity has increased in all GY areas throughout the Community. This is believed to be the result of increased use of electrical appliances (stereos, televisions, etc.) in living quarters (family housing and barracks) and office computerization (i.e. micro computers, word processors, copiers, etc.) in office areas.

3.0 ENERGY MODEL

3.1 Computer Modeled Facilities

Certain facilities in the Community were designated in the Scope of Services for computer modeling on the basis of their being representative "typical" samples of other similar types of facilities in the Community.

Computer analyses of each model were performed to determine peak loads and annual energy requirements to meet facility energy needs for heat, domestic hot water, lighting, receptacle power, equipment power and special process systems. These energy requirements then served as a data base which could be factored to arrive at energy requirements for all similar facilities not modeled. A summary of the energy requirements for the "typical" facilities, which were computer modeled, is presented in Appendix Table A-1

3.2 Heating Plant Efficiencies

Energy for facility heat and domestic hot water requirements is, for the most part supplied by heating plants. The heating plants have been categorized by size as follows: single building heating plants; multiple building heating plants, which serve less than five buildings or have less than 10 million Btu installed capacity; central heating plants which serve five or more buildings or exceed a 10 million Btu installed capacity; and lastly electric heating. A summary of the heating plants in the Community is as follows:

	AREA SERVED		INSTALLED CAPACITY		
PLANT TYPE	TOTAL SQ.FT.	(%)OF TOTAL	MILLION BTU	(%)OF TOTAL	AVG. OUTPUT BTU/SQ.FT.
SINGLE	738,399	13	56,966	13	79,700
MULTIPLE	1,026,008	18	110,000	23	106,200
CENTRAL	3,761,899	68	293,697	62	78,000
ELECTRIC	25,574	1	9,290	2	337,400
TOTAL	5,551,880	100	470,156	100	Avg.= 84,684

Heating plant efficiencies were determined for each heating plant. The efficiency relates fuel energy input to energy output delivered to the facilities. The difference between the two is energy output loss at the boiler which results from combustion, radiation, unburned fuel (coal), blowdown and losses in the system resulting from distribution, flashing (steam systems), and leakage.

3.3 Generic Facilities

Energy consuming facilities in the Community not computer modeled were designated as "generic" facilities since each was generically classified to a computer modeled facility based on its similarity to the model. Energy requirements for each generic facility were derived from the energy requirements of the modeled facility considered similar.

3.4 Community Energy Model

An energy model for the Community was developed using a computerized data base system. Input data to the model included the following: primary categories of energy requirements calculated for each computer model facility, physical characteristics (length, width, height, percent of glass, etc.) of each energy consuming facility (both models and generics) and heating plant capacities and efficiencies. Procedures were developed for the energy model which adjust the model facility energy requirements to a generic facility based on dimensional or area differences between the model facility and the generic facility to arrive at energy requirements for the generic facility.

Energy requirements are summarized by heating plant and after application of heating plant efficiency data the fuel energy input was determined for each plant.

3.5 Calculated Energy Consumption

The fuel energy consumption for each heating plant was totaled and the resultant calculated Community Energy Consumption determined. Table 1 presents the results of the calculated energy consumption for each GY Area in the Community and compares it to the "Source Consumption" recorded in FY 82.

The results of the comparison between the recorded or "Source Consumption" and the "Calculated Consumption" are as follows:

RECORDED OR "SOURCE CONSUMPTION"

Electricity	-	27,554,707 kWh	or	319,635 x 10^6 Btu
Distillate Fuel Oil (No. 2)	-	2,451,755 Gal.	or	340,058 x 10^6 Btu
Residual Fuel Oil (No. 6)	-	257,210 Gal.	or	37,295 x 10^6 Btu
Coal	-	6,484 MT	or	181,487 x 10^6 Btu
				878,475 x 10^6 Btu

CALCULATED CONSUMPTION

Electricity	-	26,788,655 kWh	or	310,748 x 10^6 Btu
Distillate Fuel Oil (No. 2)	-	2,407,249 Gal.	or	333,885 x 10^6 Btu
Residual Fuel Oil (No. 6)	-	249,440 Gal.	or	36,169 x 10^6 Btu
Coal	-	6,529 MT	or	182,747 x 10^6 Btu
				863,549 x 10^6 Btu

Difference = (863,549 -878,475)/878,475 = -.017 or -1.7%

The "Calculated Consumption" was found to be 1.7% less than the FY 82 "Source Consumption", which was within the 10% limit required by the Scope of Services. This test verifies that the model is an acceptable representation of the community energy consumption.

TABLE 1

ENERGY BALANCE - DARMSTADT MILCOM
1982 RECORDED VS ENERGY MODEL CALCULATED

GY	NO. 2 OIL GALLONS			NO. 6 OIL GALLONS			COAL METRIC TON			ELECTRIC KWH		
NO	RECORDED	CALCULATED	% DIFF.	RECORDED	CALCULATED	% DIFF.	RECORDED	CALCULATED	% DIFF.	RECORDED	CALCULATED	% DIFF.
014	278,450	290,218	+ 4.2	---	---	--	---	---	--	2,317,740	2,141,340	- 7.6
037	170,470	156,043	- 8.5	---	---	--	---	---	--	1,341,220	1,479,916	+10.3
043	---	---	--	---	---	--	---	---	--	24,994	23,376	- 6.5
069	454,769	434,619	- 4.4	---	---	--	1,728	1,756	+ 1.6	5,614,330	5,208,672	- 7.2
100	495,336	529,160	+ 6.8	181,227	171,509	- 5.4	---	---	--	4,630,340	4,579,866	- 1.1
143	30,569	289,405	- 3.7	---	---	--	---	---	--	1,539,200	1,730,476	+12.4
178	---	---	--	---	---	--	4,332	4,312	- 0.5	4,289,344	4,147,949	- 3.3
313	49,391	53,249	+ 7.8	75,983	77,931	+ 2.5	---	---	--	1,821,520	1,698,606	- 6.7
377	361,476	322,178	-10.9	---	---	--	---	---	--	1,554,040	1,409,703	- 9.3
409	6,510	6,890	+ 6	---	---	--	---	---	--	224,460	225,171	+ 0.3
423	35,492	33,577	- 5.4	---	---	--	---	---	--	661,420	661,854	+ 0.0
591	4,720	4,317	- 8.5	---	---	--	---	---	--	1,163,470	1,163,147	- 0.0
725	45,630	50,720	+11	---	---	--	---	---	--	W/GY 069	---	--
806	207,642	197,379	- 5	---	---	--	---	---	--	1,500,080	1,442,580	- 3.8
807	---	---	--	---	---	--	423	461	+ 8.8	370,330	376,379	+ 1.6
908	39,886	38,042	- 4.6	---	---	--	---	---	--	486,360	481,045	- 1.1
977	1,414	1,452	+ 2.6	---	---	--	---	---	--	15,859	15,575	- 1.8
TOT	2,451,755	2,407,249	-	257,210	249,440	-	6,484	6,529	-	27,554,707	26,788,655	-

3.6 Community Energy Consumption by Use (Audit)

The energy consumption calculated for the Community was audited to identify both the categories of energy requirements and the quantity of energy in each category. This audit identified the energy requirement impact of each category in relation to the total energy required for the Community. This parameter serves as an indicator in identifying which categories should be analyzed for Energy Conservation Opportunities (ECOs) to effectively reduce the Community energy requirement.

The results of this analysis are presented in Table 2 and are based on the calculated energy consumption.

Several important observations can be made in review of that table as follows:

- In terms of total energy consumption fossil fuel comprises 64% of the total, while electricity comprises only 36% of the total. In addition, 70% of the energy cost is fossil fuel, while electricity comprises only 30%.

- Fossil Fuel is consumed primarily in providing facility heat. An examination of the use of fossil fuel indicates that 84% is for facility heat while only 16% is consumed to provide domestic hot water.

- An examination of the use of electricity indicates that Lighting and Receptacle Power comprises 71% of the electrical consumption, at 32% and 39% respectively. Note is made that use of electricity in these two categories is discretionary and results from occupant use.

- Other use categories of electricity which are noteworthy are Pumps/Fans and Miscellaneous which comprise 15% and 11% respectively of the total electrical consumption. The latter is important since it is mission related and cannot be reduced. The former results from the Community heating systems and mess hall kitchen fan systems.

TABLE 2

CALCULATED COMMUNITY ENERGY AUDIT BY USE

ENERGY TYPE/USE	CONSUMPTION MILLION BTU	CONSUMPTION PERCENT OF TOTAL	CONSUMPTION PERCENT BY TYPE	COST DOLLARS	COST PERCENT OF TOTAL
FOSSIL FUEL					
Heating:					
No. 2 Oil	279,485	32.4	50.7	$2,800,420	45.6
No. 6 Oil	31,736	4	6.3	191,610	3.3
Coal	149,645	17	26.6	568,710	9
Subtotal Heating	460,866	53.4	83.6	$3,560,740	57.9
Domestic Hot Water:					
No. 2 Oil	54,400	6	9.0	545,100	9
No. 6 Oil	4,433	0.5	.1	26,770	0.4
Coal	33,102	4	6.3	122,810	2
Subtotal DHW	91,935	10.5	16.4	$ 694,680	11.4
Subtotal Fossil Fuel...	952,701	63.9	100%	$4,255,420	69.3
ELECTRICITY					
Heating	9,290	1	3.0	$ 51,560	1
Domestic Hot Water	766	0.1	0.2	4,600	0.1
Lighting	98,464	11	31.8	593,700	9.7
Power*	120,606	14	39.0	727,300	11.9
Pumps/Fans	48,049	6	15.0	289,700	5
Miscellaneous**	34,277	4	11.0	206,700	3
Subtotal Electricity...	310,748	36.1	100%	$1,873,560	30.7
TOTAL	863,549	100%		$6,128,980	100%

* "Power" - Washers, Dryers, Receptacles, Kitchen Equipment (mess hall)
** "Miscellaneous" - Outdoor lights, Radio Transmitters, Air Conditioning, Computers

ENERGY COST UNITS

No. 2 Oil - $10.02/1,000,000 Btu
No. 6 Oil - 6.04/1,000,000 Btu
Coal - 3.80/1,000,000 Btu
Electricity - 6.03/1,000,000 Btu

3.7 Community Energy Consumption by GY Area

The calculated energy consumption for the Community was totalized by GY areas to identify those that are large consumers of energy. This information is presented as follows:

GY NO.	GY NAME	ENERGY CONSUMING FACILITIES TOTAL NO.	FLOOR AREA SF	PERCENT OF AREA	ENERGY CONSUMPTION MILLION BTU	(%)OF TOTAL	BTU/SF
591	- ETF	1	6,369	0.1	14,093	2.0	2,212,750
043	- WAA	1+1*	132	0	271	-	2,053,300
100	- CFK	48	910,688	16.6	151,389	17.0	166,236
806	- JVFH	13	354,386	6.5	44,110	5.0	124,469
313	- NHQA	24+1*	389,586	7.1	38,390	4.0	98,540
377	- KB	20	403,678	7.3	61,038	7.0	151,205
143	- ELK	28	408,574	7.4	60,214	7.0	147,376
014	- GAF	33	333,087	6.0	65,127	8.0	195,525
908	- DCC	4	77,166	1.4	10,856	1.0	140,684
423	- GMF	6	18,989	0.3	12,335	1.5	649,587
178	- LVFH	38	1,245,860	22.7	168,809	20.0	135,496
807	- SBVFH	20	83,045	1.5	17,269	2.0	207,947
069	- BK	66+1*	547,051	10.0	169,853	20.0)	245,337
725	- BFH	21	561,861	10.2	7,035	1.0)	
037	- MAD	33+1*	159,140	2.8	38,810	4.0	243,873
977	- MSAR	1+1*	3,000	0.05	382	-	127,333
409	- MRRS	4	3,238	0.05	3,568	.5	1,019,147
TOTAL		361+5*	5,505,850	100.0	863,549	100.0	156,842 (GY Avg.)

(*Non-Facility Function)

Summary comments regarding these results are as follows:

- Several GY Areas appear to have a large energy use in terms of BTU/SF. This has resulted from the installation of extensive mission related communications equipment as compared to the amount of floor area. This was found to be the case for GY 591 (Egelsbach), GY 423 (Griesheim Missile) and GY 409 (Melibokus).

- A high energy use for GY 043 (Walldorf) results from the extensive mission related outdoor lighting.

- The most important thing to observe on this table is that for GY Areas containing barracks or family housing, there is almost a one-to-one relationship between the GY facility floor area as a percent of the Community floor area and the energy consumed by the GY as a percent of the total Community consumption.

3.8 Community Energy Requirement by Facility Type

The facilities in the Community were grouped by type according to similarity and functional use. The energy requirements for each type were totaled from the energy model calculations. The energy requirements for each facility type are presented as follows:

TYPE CODE/DESCRIPTION	NO. THIS TYPE	TOTAL AREA SQ.FT.	(%)OF AREA	TOTAL ENERGY REQUIRED MILLION BTU	(%)	BTU/SF
A-Admin/Hdqrtrs	37	476,375	9	56,341	9	118,270
B-Barracks	41	1,117,288	20	99,229	17	88,812
C-Barracks-Admn/Hdqtr	5	131,631	2	13,002	2	98,775
D-Mess	14	180,378	3	48,730	8	270,302
E-Service Club	4	61,639	1	9,362	2	151,886
F-Repair/Maintenance	43	337,960	6	50,011	8	147,978
G-Recreation	25	226,949	4	29,490	5	129,940
H-Housing	84	2,149,752	39	193,662	33	90,086
I-Training	6	72,659	1	6,478	1	89,154
J-School/Classroom	10	120,486	2	12,097	2	100,401
K-Post Exchange	10	123,670	2	8,097	1	65,474
L-Storage/Warehouse	28	383,824	7	19,778	3	51,529
M-Special Use	11	91,107	2	23,089	4	253,247
N-Electric Heated	43	32,132	1	20,281	3	631,176
Z-Non-Facility Function*	5*	---	--	6,160	1	---
TOTALS	361+5*	5,005,850	100	595,807	100	119,022

Comments regarding the results of this summary are as follows:

- By combining family housing and barracks it is found that living quarters comprise 59% of the total Community area, and 50% of the total community energy requirement. Family housing comprises 39% and 33%, area to energy and barracks is at 20% and 17% respectively. However, in terms of the BTU/SF both are well below the Community average of 119,022.

- The use of electricity for heating occurs in only 1% of the Community area, however it comprises 3% of the Community energy requirement, which results in the highest unit requirement of over 600,000 BTU/SF.

These results are also presented graphically in Appendix Figures A-6, A-7 & A-8.

4.0 PROJECTED ENERGY CONSUMPTION

4.1 Calculated Future Consumption (FY 85)

The energy model was used to calculate a projected consumption of energy for the Community in FY 85. In order to accomplish this it was necessary to modify the facility data and heating plant data to simulate known and funded energy conservation improvements. Any facility expansion projects currently being implemented by the Community or funded with completion projected in time to impact on the FY 85 energy consumption were factored into the energy model.

Data for the projects, i.e., a description and facilities affected, was obtained from the Community. Escalation of fuel costs was based on Government furnished data.

The Projected Energy Consumption and cost for FY 1985 is as follows:

ENERGY SOURCE	CONSUMPTION MILLION BTU	PERCENT OF TOTAL	COST DOLLARS	PERCENT OF TOTAL
Electricity	319,972	36	$2,427,375	32
Distillate Fuel Oil (No.2)	287,342	33	3,625,442	48
Residual Fuel Oil (No. 6)	68,118	8	530,848	6
Coal	183,922	21	881,171	12
Gas	14,026	2	191,406	2
Total	873,380	100	$7,606,242	100

4.2 FY 85 Compliance with AFEP

A comparison of the calculated FY 85 projected energy consumption with the recorded FY 75 energy consumption yields an approximation of compliance with the AFEP as follows:

ENERGY SOURCE	PERCENT CHANGE
Electricity	+ 23
Distillate Fuel Oil (No.2)	- 20
Residual Fuel Oil (No.6)	+ 80
Coal	- 15
Gas	- 23
Net	- 2

5.0 ENERGY CONSERVATION OPPORTUNITIES

5.1 Energy Conservation Opportunities Considered

Energy Conservation Opportunities considered for evaluation as part of this EEAP were obtained from three sources: Annex "C" of the Scope of Services (USAREUR), K/L past experience on similar energy analyses, and evaluation of existing conditions based on site observations.

Potential ECOs which impact on energy consumption were evaluated using Energy Conservation Investment Program (ECIP) Guidelines to calculate a Savings to Investment Ratio (SIR). When the SIR Value is one (1) or greater the ECO is a candidate for implementation.

5.2 Facility Improvement ECOs (Increment "A")

These ECOs include modifications, improvements and retrofits of existing buildings.

ECOs were evaluated by first performing a preliminary analysis using computer modeled buildings. When this analysis resulted in an acceptable SIR Value, the ECO was evaluated for Community wide implementation.

ECOs evaluated are as follows:

ECO DESCRIPTION	SIR
Facility Space Temperature Reduction	28.3
Insulate Condensate Piping (1" insulation)	9.0
Insulate Condensate Piping (2" Insulation)	-
Insulate Valves	1.6
Weatherstrip Doors and Windows	13.4
Weather Responsive Controls	3.9
Reduce Domestic Hot Water Temperature	55.1
Roof Insulation	3.0
Kitchen Hood Air Make-up	1.6
Thermal Curtains - Motor Repair Shops	6.2
Flow Restrictors (DHW)	3.4
Electric Heater Replacement with Oil Heater	5.9
Indoor Lighting, Incandescent to Fluorescent	1.2
Exterior Lighting, Incandescent to Fluorescent	1.8
Facility Heating Zones	0.5
Wall Insulation (add to existing facilities)	0.9
Double Pane Windows	0.5
Thermal Doors (replace existing)	2.3
Vestibules at Exterior Door	0.7
Photo Cell Switches - Indoor Lighting	0.1

ECO DESCRIPTION	SIR
Time Clock Control - Indoor Lighting	9.2
Outdoor Lighting - Fluorescent to H.P. Sodium	0.5
Outdoor Lighting - Mercury Vapor to H.P. Sodium	0.8
High Efficiency Fluorescent Lamps (Relamp)	0.2
Screw Type Fluorescent Lamps (Repl. Incandescent)	1.9
High Efficiency Fluorescent Ballasts	.5
Time Clock Control Kitchen Exhausts	150.0

5.3 Central Plant/Energy Distribution ECOs (Increment "B")

These ECOs include improvements and modifications to utility and energy distribution systems, EMCS systems, and energy plants.

These ECOs were evaluated on an individual basis, i.e., for each central plant where the ECO was considered feasible based on engineering judgement. The analysis results were summarized for each ECO based on implementation at each central plant where the calculated SIR Value was greater than 1.

These ECOs evaluated are as follows:

ECO DESCRIPTION	SIR
Insulate Piping Valves and Tanks	8.0
Boiler Draft Regulators	4.8
Boilers Sequencing Controls	1.6
Interconnect Heating Plants	5.6
Summer Boilers for DHW	4.3
Extended Service Summer Boilers	0.4
Jet Condensate Pumps	0.1
Coal-Fired Boiler Conversion	0.6
Replace Inefficient Boilers	1.7
Convert Heating Medium Distributed	0.3
Down Size Burners	0.32
Combustion Air Preheaters	0.61
Recover Heat from Blowdown	1.18
Carrier Current Control System	1.02
Energy Monitoring and Control Systems	2.40

5.4 Recommended Energy Conservation Opportunities

A total of 22 Energy Conservation Opportunities, which meet ECIP Criteria, were recommended for implementation in the Community. These ECOs are presented in Table 3 with the results of the economic analyses performed for each ECO which had an SIR greater than 1.

TABLE 3

LIST OF RECOMMENDED ECO'S WITH COMMUNITY WIDE ESIR OR SIR >1

NUMBER AND RANK	ECO DESCRIPTION	INCREMENT	ENERGY SAVINGS (MMBTU)	COST SAVING ($)	DISCOUNTED SAVING ($)	COST TO IMPLEMENT ($)	SIR	ESIR
1	Domestic Hot Water Temperature Reduction	A	5,500	39,100	485,000	8,800	55.1	55.1
2	Boiler Draft Regulators	B	11,000	47,400	698,370	15,600	44.8	44.8
3	Building Space Temperature Reduction	A	98,000	756,000	9,101,400	321,000	28.3	28.3
4	Weatherstrip Doors & Windows	A	12,400	102,000	1.216.000	91,000	13.4	13.4
5	Insulate Condensate Piping in Buildings	A	1,160	11,000	126,000	14,000	9.0	9.0
6	Insulate Piping & Vessels in Htg.Plants	B	3,500	27,000	330,300	41,300	8.0	8.0
7	Thermal Curtains at Motor Repair Shop	A	21,300	193,400	2,257,000	363,300	6.2	6.2
8	Replace Elec. Heaters with Oil Heaters	A	4,400	13,800	140,900	24,000	5.9	5.9
9	Interconnect Heating Plants	B	5,090	50,900	578,520	102,700	5.6	5.6
10	Summer Boilers	B	7,500	56,060	681,000	158,900	4.3	4.3
11	Weather Responsive Controls	A	42,500	394,000	4,559,000	1,148,000	4.03	4.03
12	Flow Restrictors(DHW)	A	7,860	50,780	438,100	108,700	3.4	3.4
13	Add Roof Insulation to Building	A	98,730	712,600	8,810,200	2,811,000	3.0	3.0
14	Indoor Lighting Repl Incd W/Fluor	A	7,780	30,010	313,830	151,000	2.4	2.4
* 15	EMCS	B	42,430	394,000	4,559,000	2,048,5800	2.1	2.1
16	Entrance Lighting Repl.Incand.W/Fluor.	A	1,050	6,300	69,600	36,700	1.9	1.9
17	Boiler Replacement	B	300	2,900	32,440	19,000	1.7	1.7
18	Boiler Sequencing Controls	B	300	2,870	32,640	20,000	1.6	1.6
19	Insulate Valves in Facilities	A	780	5,660	70,000	45,000	1.6	1.6
20	Kitchen Hood Make-Up Air	A	3,400	32,400	394,500	324,800	1.2	1.2
21	Recover Heat from Boiler Blowdown	B	130	800	10,620	10,000	1.1	1.1
22	Carrier Current	G	0	41,051	451,960	400,200	1.02	0

*This ECO is not recommended for implementation since Stand-alone Weather Responsive Controls result in a higher SIR Value.

ECOs, which met ECIP criteria but were not recommended for implementation are as follows:

- New Thermal Doors - ECO for weatherstripping resulted in a higher SIR.
- Time Clock Controls - Field data observations indicated that time clocks were not required for either indoor lights or kitchen exhausts.
- Screw-in Type Fluorescent Lamps - Application limited to fixtures without a lens housing, i.e., typically table lamps found in family housing, therefore implementation would have to be through occupants.

5.5 ECIP Projects

ECIP projects include those Energy Conservation Opportunities which, when grouped together in accordance with the Community's requests, meet Energy Conservation Investment Program criteria and can therefore be implemented through ECIP funding.

DD 1391 Forms and Project Development Brochures (PDP-1's) were subsequently prepared for each project which incorporate a conversion rate of $1 = 2.56 DM and an annual escalation rate of 8%. The projects were programmed for funding in FY 87.

The projects are listed in order of decreasing SIR Value as follows:

PROJECT RANK/NO.	PROJECT DESCRIPTION	ECO NO.	INCRE-MENT	FACILITY TYPE	FUNDING $ x 1000	PROJECT SIR	PROJECT ESIR
1	Heating Plant Projects	9,10,18	B	MCA	589.3	4.08	4.08
2	Weather Responsive Cont.	11	A	MCA	1,591.8	3.75	3.75
3	Attic/Roof Insulation	13	A	MCA	2,835.1	3.31	3.31
4	Thermal Curtains	7	A	MCA	512.3	3.15	3.15
5	Attic/Roof Insulation	13	A	F.H.	1,122.4	2.01	2.01
6	Entrance Lights	16	A	F.H.	33.6	1.84	1.84
7	Kitchen Hood/Makeup Air	20	A	MCA	423.0	1.32	1.32
8	Weather Responsive Cont.	11	A	F.H.	27.2	1.01	1.01

5.6 Other Projects

"Other Projects" include all other Energy Conservation Opportunities which, when grouped together in accordance with the Community's request, do not meet Energy Conservation Investment Program criteria and, therefore cannot be ECIP funded.

The project documentation prepared for these projects in accordance with the Community request include "1391/PDB-1" documents and "4283" (Work Order) documents. Special note is made that multiple "4283's" were prepared for each project; a "4283" was prepared for each heating plant; for the other projects a separate "4283" was prepared for each GY Area where the ECO was to be implemented.

The documents developed are as follows:

PROJECT RANK/NO.	PROJECT DESCRIPTION	ECO NO.	DOCUMENT TYPE	INCREMENT	FACILITY TYPE FUNDING $x1000 MCA	FH	PROJECT SIR	ESIR
1	DHW Temp. Reduc.	1	1391	G	5.54	5.74	55.1	55.1
2	Space Temp. Reduction	3	4283	G	MCA	360.7	26.60	26.60
3	Htg.Plant Improvements	2,6,21	1391	G	53.2	0	16.70	16.70
4	Space Temp. Reduction	3	4283	G	F.H.	118.2	16.04	16.04
5	Weatherstrip	4	4283	G	61.23	33.55	13.4	13.4
6	Insulate Pipes	5	4283	G	17.3	-	9.0	9.0
7	Elec/Oil Htr. Conv.	8	4283	G	22.0	-	5.9	5.9
8	Flow Restrictors	12	4283	G	64.2	62.5	3.4	3.4
9	Indoor Lights	14	4283	G	-	209.50	2.4	2.4
10	Entrance Lights	16	1391	G	11.87	-	2.0	2.0
11	Insulate Valves	19	4283	G	32.2	15.8	1.6	1.6
12	Carrier Current Control	22	4283	G	MCA/FH	501.0	1.77	-

5.7 Energy Consumption with ECOs Implemented

Energy consumption for the Community was calculated using the energy model modified to reflect implementation of the ECOs recommended. The results of that analysis yielded a resulting energy consumption as follows:

ENERGY SOURCE	CONSUMPTION BTU X 10^6	PERCENT OF TOTAL	COST DOLLARS	PERCENT OF TOTAL
Electricity	301,551	49	$2,668,800	44
Distillate Fuel Oil (No.2)	161,281	26	2,374,100	39
Residual Fuel Oil (No.6)	33,642	6	306,140	5
Coal	104,561	17	584,500	9
Gas	14,026	2	104,935	3
Total	615,061	100	$6,038,475	100

5.8 Compliance with AFEP

With the implementation of the energy conservation opportunities recommended, the change in energy consumption as compared to the "Baseline Consumption" for FY 75 will be as follows:

ENERGY SOURCE	PERCENT CHANGE
Electricity	+ 16
Distillate Fuel Oil (No.2)	- 54
Residual Fuel Oil (No.6)	- 16
Coal	- 52
Gas	- 22
Net	- 31

Appendix Figures A-9 and A-10 graphically present the change in consumption and cost from FY 75 to FY 85 (with ECOs) for each energy type.

6.0 COMMUNITY IMPLEMENTED ENERGY CONSERVATION MEASURES

6.1 Operational & Maintenance Procedures

Operational and maintenance measures should be performed on a scheduled basis in order to yield in energy savings. Measures identified requiring implementation by the Community are as follows:

- Maintenance program for all mechanical and electrical equipment.
- Adjust and/or clean oil boiler burners.
- Perform boiler combustion efficiency tests with electronic instruments.
- Check equipment time clock operation and settings.
- Check weather responsive controls setback schedule.
- Inspect steam traps.
- Provide water treatment for boiler water makeup.
- Perform boiler blowdown to remove mineral deposits.
- Recalibrate central plant instrumentation.
- Install electric meters in Family Housing/Barracks.

6.2 Building Occupant Energy Awareness Programs

Facility occupants should be made aware of methods that they can implement to reduce energy waste, these are:

- Shut off lights and equipment when not used.
- Close radiator valves, lower thermostats. Do not open windows in winter.
- Lower space temperature when out of building.

6.3 Training

The central plant operators must be thoroughly trained in the operation of the boiler plants. Training instruction/courses are available for operators from the following sources:

- Boiler Efficiency Institute", P.O. Box 2255, Auburn, Alabama, USA (36830)

- Viessmann Boiler Co., 2-day instruction at Facility or Viessmann Offices, Fee 2800 DM. Contact Mr. Hencker (0611-692033-35)

6.4 Equipment Replacement

When existing equipment fails due to age or condition, the replacement equipment selected should be high efficiency types to obtain energy savings. Examples of this are:

- Relamp with high efficiency "WATTMISER" fluorescent lamps.
- New boilers size should match current peak heating load requirement and not existing boiler nameplate data.

- Replace faulty boiler burners with proper efficient units to match load.
- Install separate domestic hot water heaters for summer requirements so so that base heating plant boilers can be shut-down in the summer.
- Install controls to limit domestic hot water to 105°F.
- Install high efficiency motors.
- Replace steam heating systems with hot water when renovating.
- Install high efficiency ballasts in fluorescent fixtures.
- Install tamperproof radiator valves that fail closed.
- Relamp incandescent fixtures with screw-in type fluorescent lamps.
- Install electrical transformers matched to recorded demand peaks.

7.0 SUMMARY AND RECOMMENDATIONS

7.1 General

The objective of this project is to reduce energy consumption by the Community in accordance with the goals of the Army Facilities Energy Plan (AFEP). Specifically, this plan calls for reducing consumption such that the FY 85 consumption is 20% below the FY 75 consumption.

7.2 Existing Energy Situation

Energy consumption for FY 75 was designated to be the "Baseline Consumption." From Community records it was found that in FY 75, the Community had consumed 890,201 x 10^6 Btu's of energy at a cost of $2,725,204.

By FY 82, when this study was performed, energy consumption had changed to 892,500 x 10^6 Btu which was a net 0.4% increase above the consumption of FY 75. In addition, energy cost had changed to $6,364,400. Consumption had remained at the same level since the Community has implemented energy conservation measures to reduce the consumption of fossil fuel which offset an increased consumption of electrical energy.

Physical changes are planned for the Community which will affect future consumption. Those changes include conservation measures consisting of facility improvements and also heating plant consolidation, which will result in a reduction of consumption. However, projects are also planned which will increase the Community facility area and thus increase consumption. Those funded, were programmed into the energy model to project consumption for FY 85. The net results include a decrease in total consumption by FY 85 to 873,380 x 10^6 Btu with a projected cost of $7,606,242.

The change in consumption is summarized as follows:

FY YEAR	TOTAL CONSUMPTION MILLION BTU	PERCENT CHANGE SINCE FY 75
75	890,201	
82	892,500	+ 0.4
85	873,380	- 2

In review of this it can be seen that compliance with the AFEP, i.e., reduction of 20% by FY 85 will not be achieved under the current Community plans.

7.3 Community Energy Audit

A computerized energy model was developed for the Community. This model served two purposes: it provided a means to evaluate the impact of ECOs on Community energy consumption and in addition, it provided a means to perform an audit of the Community energy consumption to determine how energy is used and conversely where reduction should be made.

Based on the audit, the major categories of consumption, ranked by quantity are as follows:

NO./RANK	ENERGY CATEGORY	PERCENT OF TOTAL ENERGY
1	Facility Heat	54.4
2	Receptacle Power	14
3	Facility Lighting	11
4	Domestic Hot Water Heating	10.6
5	Distribution Equipment Power (Pum/Fans)	6
6	Miscellaneous Power	4

It was also determined from the audit that by energy source, fossil fuel (categories 1 and 4), comprises 64% of the energy consumed and electricity the remaining 36%.

7.4 Energy Conservation Opportunities (ECO)

The greatest amount (62%) of energy consumed by the Community is in the form of fossil fuel for heating of facilities and domestic hot water. Many ECOs were identified and, based on evaluation results, were found to quality for implementation and thus reduce the consumption of fossil fuel. These ECOs included bringing facilities and systems into compliance with Army mandated temperatures (i.e., facilities at 65°F during the day and 55°F at night), increasing the thermal resistance of facilities by installing insulation, modification and consolidation of heating plants to increase system efficiencies, and lastly adding

controls to heating systems to use the heating media more effectively. Through implementation of these measures, fossil fuel consumption will reduce to 49% of the total, with its change since FY 75 presented as follows:

FY YEAR	CONSUMPTION FOSSIL FUEL MILLION BTU	(%)of TOTAL	PERCENT CHANGE FROM FY75
75	614,550	69%	-
82	558,840	62%	- 2
85	539,382	62%	- 12
with ECOs	299,482	49%	- 51

Electricity comprises 36% of the total energy currently consumed in the Comunity. The use categories of electrical energy are as follows: were receptacle power (14%), facility lighting (11%), heating media distribution equipment power (6%), miscellaneous (mission related) systems (4%), facility heat (1%) and domestic hot water (0.1%). Many ECOs were identified and, based on evaluation, some do qualify for implementation, however, there is a real lack of physical improvements in the form of ECOs impacting on consumption.

The apparent reason of this lack of ECO projects can be traced to the categories of electrical energy use. Specifically, the primary categories having an impact, are receptacle power and facility lighting, which comprise 14% and 11% respectively of the 36% total. ECOs were developed for these categories that include installation of more efficient fluorescent lighting to reduce energy consumption and a carrier current control system that will reduce electrical demand cost but not consumption. Other ECOs were not found to be cost effective. In addition, the energy consumption in these two categories is totally discretionary; receptacles and lights are controlled by facility occupants. Since family housing and barracks comprise 59% of the total floor area and 50% of total energy consumption, the impact of the many appliances (TV's, stereos, video cassette recorders, phonographs, refrigerators and especially electric clothes dryers is significant.

With regards to the other categories, the distribution equipment consists for the most part of pumps distributing hot water for heating to the facilities. The miscellaneous use is for the most part mission related consisting of communication equipment and security lighting. Reduction in either of these categories is not feasible.

The remaining electrical ECO is for the installation of oil heaters in Facilities (mostly Sentry Stations) which are currently electrically heated. While this ECO will reduce electrical consumption it will result in an increase of fuel oil consumption. Savings will be realized since fuel oil is a less expensive form of energy than electricity.

Through implementation of the ECO projects identified, electrical energy consumption will decrease from the projected FY 85 level. The change in electrical consumption since FY 75 is presented as follows:

FY YEAR	ELECTRICITY CONSUMPTION MILLION BTU	(%)OF TOTAL	PERCENT CHANGE SINCE FY 75
75	259,478	29	-
82	319,634	36	+ 23%
85	319,972	36	+ 23%
With ECOs	301,551	49	+ 16%

7.5 Impact on Energy Situation/AFEP Compliance

The impact of implementation of ECOs on the energy situation in the Community is presented as follows:

FY YEAR	TOTAL CONSUMPTION MILLION BTU	PERCENT CHANGE SINCE FY 75
75	890,201	-
82	892,500	+ 0.3
85	873,880	- 1.8
With ECOs	615,061	- 3.1

In summary, while it will not be possible to achieve compliance with the Army Facilities Energy Plan (AFEP) by FY 75, compliance will be achieved when all ECO projects are implemented; consumption will be reduced to 31% less than FY 75, exceeding the 20% reduction required. Figure 1 graphically presents the impact of the energy savings on the total consumption occurring for FY 75.

7.6 Recommendations

K/L recommends that all ECO projects be implemented after funding is approved.

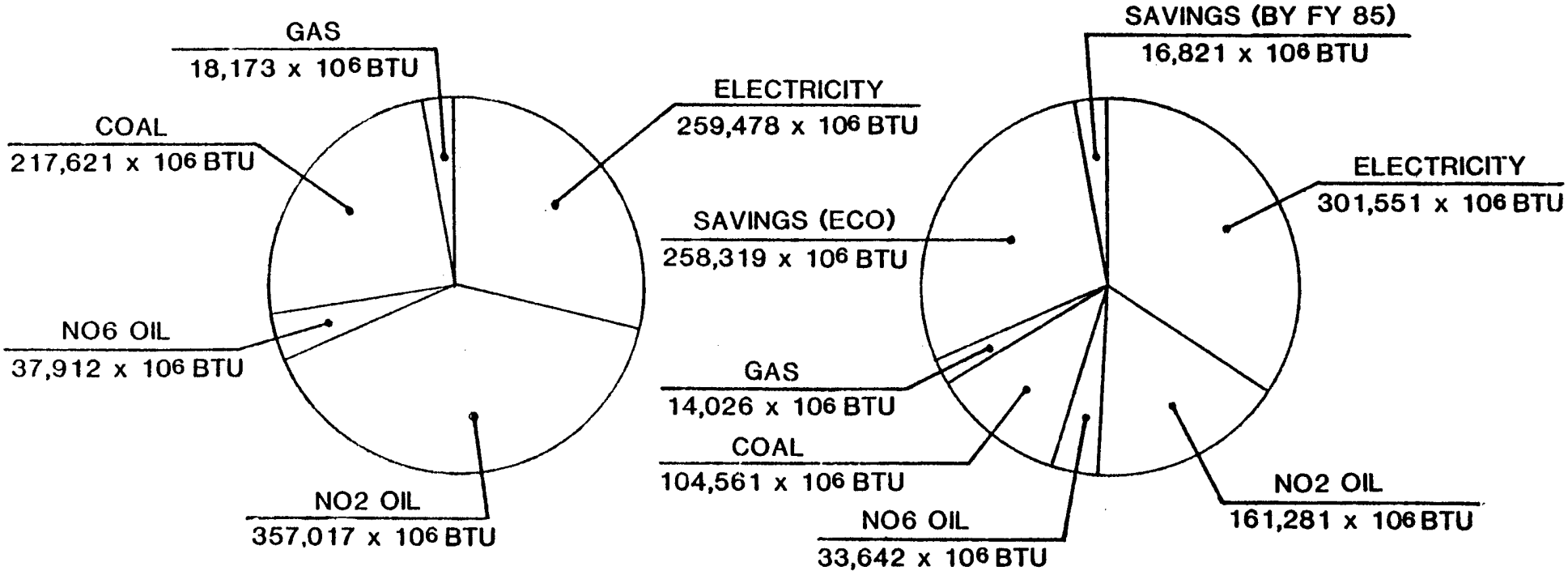
K/L recommends that emphasis be placed on reducing consumption of fossil fuel in heating plants where thermal energy is released to heat Facilities and domestic hot water. Further reductions in energy use can be made consolidating individual heating plants to central plants (not part of this study) without adverse impact on troop morale or mission.

Reduction in electrical energy consumption is limited, due to its discretionary use by troops and/or dependents and required use for mission related systems. Further reductions in consumption is possible through energy awareness programs, where troops and dependents are made aware of the impact of leaving lights and appliances on when not in use. Efforts to reduce consumption by enforcing restrictions may have an adverse affect on troop morale.

FIGURE 1

TOTAL ENERGY CONSUMPTION

FY 75 VS FY 85 W/ECOs



FY 75

CONSUMPTION 890,201 x 10⁶ BTU

FY 85 W/ECOs

CONSUMPTION 615,061 x 10⁶ BTU
TOTAL SAVINGS 275,140 x 10⁶ BTU
890,201 x 10⁶ BTU

TABLE A-1

TYPICAL COMPUTER MODELED FACILITIES

BLDG NO.	GY NO.-NAME	TYPE	BUILDING FUNCTION	AREA SQ.FT.	ENERGY TYPE AND REQUIREMENT (BTU/SQ.FT.) FOSSIL FUEL HEATING	FOSSIL FUEL DOM H W	ELECTRICITY LIGHT	ELECTRICITY POWER	ELECTRICITY PUMPS	ELECTRICITY DOM H.W	ELECTRICITY HEATING	TOTAL
4002	100-CFK	B	BKS W/O MESS	52,477	33,310	15,883	20,794	13,272	-0-	-0-	-0-	83,259
4005	100-CFK	A	DIV HQ BLDG	60,052	27,793	2,614	14,285	4,886	-0-	-0-	-0-	49,578
4006	100-CFK	C	ADMIN-BKS W/O MESS	52,595	31,466	6,579	35,222	24,547	-0-	-0-	-0-	97,815
4008	100-CFK	E	EM SERVICE CLUB	12,894	76,624	6,282	30,438	99,550	-0-	-0-	-0-	212,894
4013	100-CFK	D	ENL PERS MESS	25,832	117,064	40,260	44,174	94,925	-0-	-0-	-0-	296,424
4017A	100-CFK	G	BOWLING CENTER	19,875	54,943	-0-	2,890	32,363	-0-	-0-	-0-	90,196
4017B	100-CFK	G	GYMNASIUM	26,505	78,929	34,597	18,577	17,201	-0-	-0-	-0-	149,303
4017C	100-CFK	E	EM SERVICE CLUB	19,875	51,824	805	14,919	31,635	-0-	-0-	-0-	99,184
4019	100-CFK	L	GEN STORE HOUSE	15,503	33,947	731	5,361	5,383	-0-	-0-	-0-	45,421
4020A	100-CFK	G	REC BLDG	12,038	56,155	5,316	14,852	150,625	-0-	-0-	-0-	226,949
4020B	100-CFK	D	OPEN MESS NCO	3,868	88,676	5,688	15,610	146,769	-0-	-0-	-0-	256,743
4020C	100-CFK	M	FIXED LAUNDRY	2,705	39,926	21,072	16,622	933,197	-0-	-0-	-0-	1,010,817
4021	100-CFK	G	THEAT W/STAGE	16,783	69,356	179	11,080	1,992	-0-	-0-	-0-	82,607
4027	100-CFK	A	POST HQ/ADMIN	29,015	23,540	172	45,014	25,976	-0-	-0-	-0-	94,702
4084	806-JVFH	H	FAM HOUSING NCO	35,862	37,589	9,260	16,001	14,111	8,529	-0-	-0-	85,487
4090	806-JVFH	H	SEBQ	11,751	51,910	25,019	23,238	36,267	-0-	-0-	-0-	136,434
4092	806-JVFH	H	BOQ	29,486	42,936	8,852	23,756	22,952	-0-	-0-	-0-	98,495
4106A	313-NHQA	L	GEN PURP WHS	56,175	10,254	-0-	10,093	7,954	-0-	-0-	-0-	28,301
4106B	313-NHQA	A	ENGR ADMIN	8,052	5,216	-0-	31,704	8,023	-0-	-0-	-0-	44,943
4110	313-NHQA	A	ENGR ADMIN	62,290	53,010	177	5,887	1,646	-0-	-0-	-0-	60,719
4127	313-NHQA	F	FAC ENGR STORHSE	11,150	109,058	-0-	8,519	25,831	-0-	-0-	-0-	143,409
4165	377-KB	B	BKS W/O MESS	54,882	28,024	11,862	19,882	12,691	-0-	-0-	-0-	72,459
4171	377-KB	F	MOTOR REPAIR SHOP	33,800	39,615	-0-	16,054	623	-0-	-0-	-0-	56,303
4233A	143-ELK	K	CLO SALES STORE	1,659	7,836	4,822	10,188	24,787	-0-	-0-	-0-	47,633
4233B	143-ELK	I	SKILL DEV CNTR	6,903	1,449	579	26,245	89,928	-0-	-0-	-0-	118,201
4233C	143-ELK	I	GEN EDUCATN DEV FAC	13,806	19,050	290	12,436	7,257	-0-	-0-	-0-	39,032
4233D	143-ELK	K	POST EXCHANGE	5,244	5,721	11,823	4,329	70,533	-0-	-0-	-0-	92,406
4319	014-GAF	A	ADMIN	41,199	63,642	631	30,360	36,462	-0-	-0-	-0-	131,097
4320A	014-GAF	A	ADMIN	9,088	137,324	220	26,131	7,404	-0-	-0-	-0-	171,079
4320B	014-GAF	M	PRINT PLANT	16,805	36,001	24,695	25,033	235,932	-0-	-0-	-0-	321,662
4363	908-DCC	I	GEN EDUCATN DEV FAC	24,190	24,101	11,410	31,528	25,398	7,337	-0-	-0-	99,773
4373	908-DCC	J	DA MIDDLE SCHOOL	29,748	43,062	-0-	35,753	9,623	23,822	3,867	-0-	115,127
4400	178-LVFH	H	FAM HSG NCO	35,390	45,634	9,522	11,182	18,796	-0-	-0-	-0-	85,135
4451	807-SBVFH	H	FAM HSG LTC/MAJ	4,384	51,323	29,653	15,347	26,145	-0-	-0-	-0-	122,468
4508	069-BK	A	GP HQ/ADMIN	12,738	73,716	-0-	29,596	16,060	-0-	-0-	-0-	119,372
4511	069-BK	B	BKS W/O MESS	26,396	46,484	9,585	13,529	20,130	7,770	-0-	-0-	97,498
4523	069-BK	F	MOTOR REPAIR SHOP	23,836	94,688	-0-	29,111	3,950	24,058	-0-	-0-	151,809
4563	069-BK	A	CO HQ BLDG	4,118	109,762	971	20,183	13,073	-0-	-0-	-0-	143,990
5202	246 *	A	CO HQ BLDG	2,163	162,274	-0-	26,075	2,344	-0-	-0-	-0-	190,693
5204	246 *	F	MOTOR REPAIR SHOP	10,851	117,041	-0-	33,035	1,446	17,844	-0-	-0-	169,366
5212	246 *	C	BN HQ-BKS W/O MESS	24,088	48,697	11,334	15,696	5,212	12,166	-0-	-0-	93,105
5214	246 *	A	ENGR ADMIN BLDG	3,949	76,728	-0-	15,034	6,815	-0-	-0-	-0-	98,577
5240	026 *	M	AF OPS BLDG	8,042	258,890	373	9,597	3,012	7,988	-0-	-0-	279,860
5253	335 *	M	ADMIN/DENTL FAC	55,398	40,724	1,065	10,382	3,982	8,543	-0-	-0-	56,153
5260	335 *	J	COLD STORAGE WHSE	22,287	36,166	628	14,228	3,557	-0-	-0-	-0-	54,579
5337	562 *	N	SENTRY STATION	129	-0-	-0-	60,518	-0-	-0-	-0-	1,218,899	1,279,417
5565	510 *	M	COLD STORAGE WHSE	5,010	-0-	-0-	13,959	291,204	22,930	-0-	-0-	328,083
5572	510 *	F	FAC ENGR MAINT SHOP	21,389	97,013	-0-	11,951	39,764	-0-	-0-	-0-	148,728
5621	160 *	J	DEPN GRADE SCHOOL	40,901	56,209	269	30,436	672	10,424	-0-	-0-	98,010
5653	160 *	G	YOUTH CENTER	7,888	82,530	2,282	28,349	6,781	-0-	-0-	-0-	119,942

* GY Areas located in Bad Kreuznach Military Community

FIGURE A-1

TOTAL ENERGY CONSUMPTION BY GY AREA
(FY 75 vs FY 82)

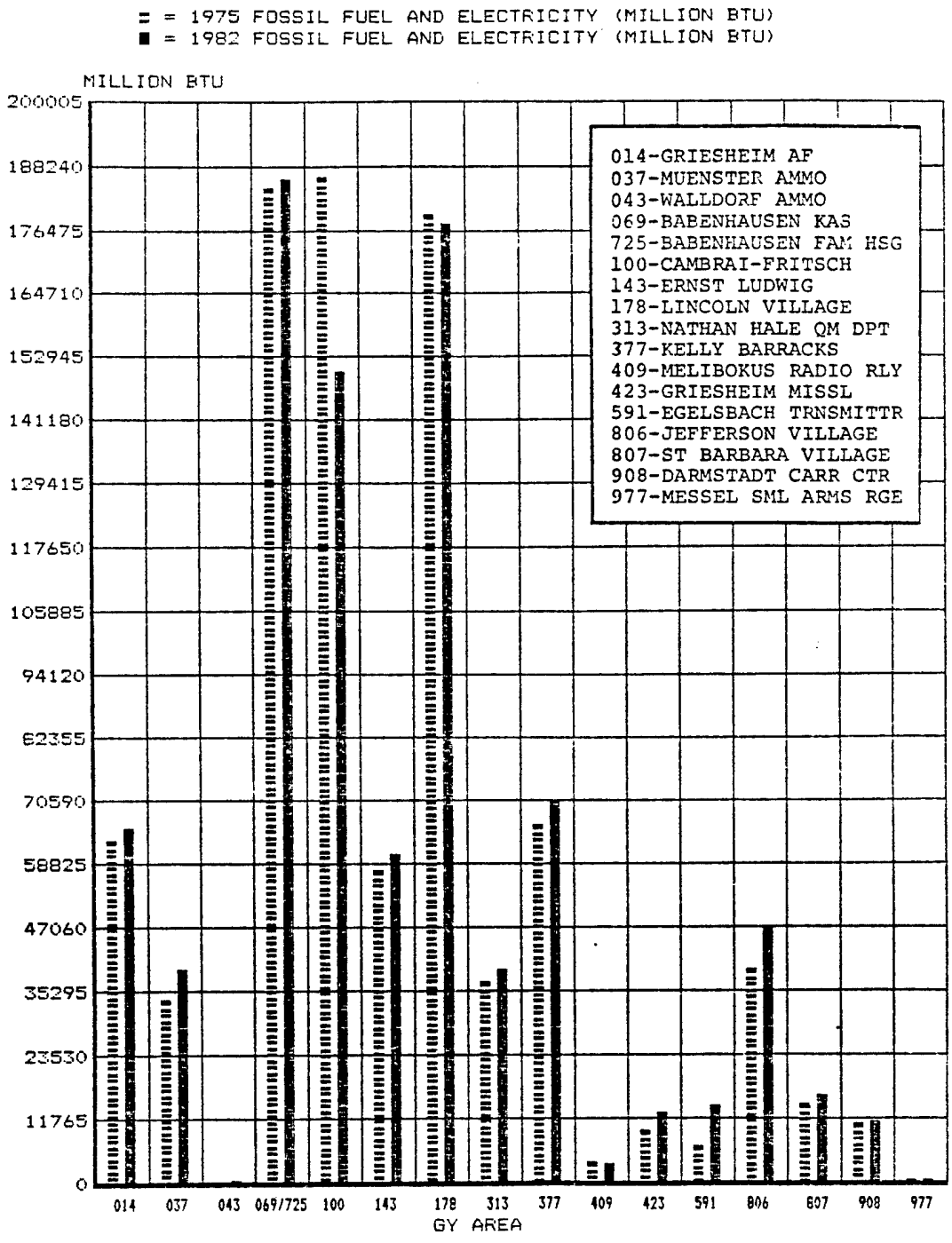


FIGURE A-2

TOTAL ENERGY CONSUMPTION/SF BY GY AREA
(FY 75 vs FY 82)

= = 1975 FOSSIL FUEL AND ELECTRICTY (btu x 1000)
■ = 1985 FOSSIL FUEL AND ELECTRICITY (btu x 1000)

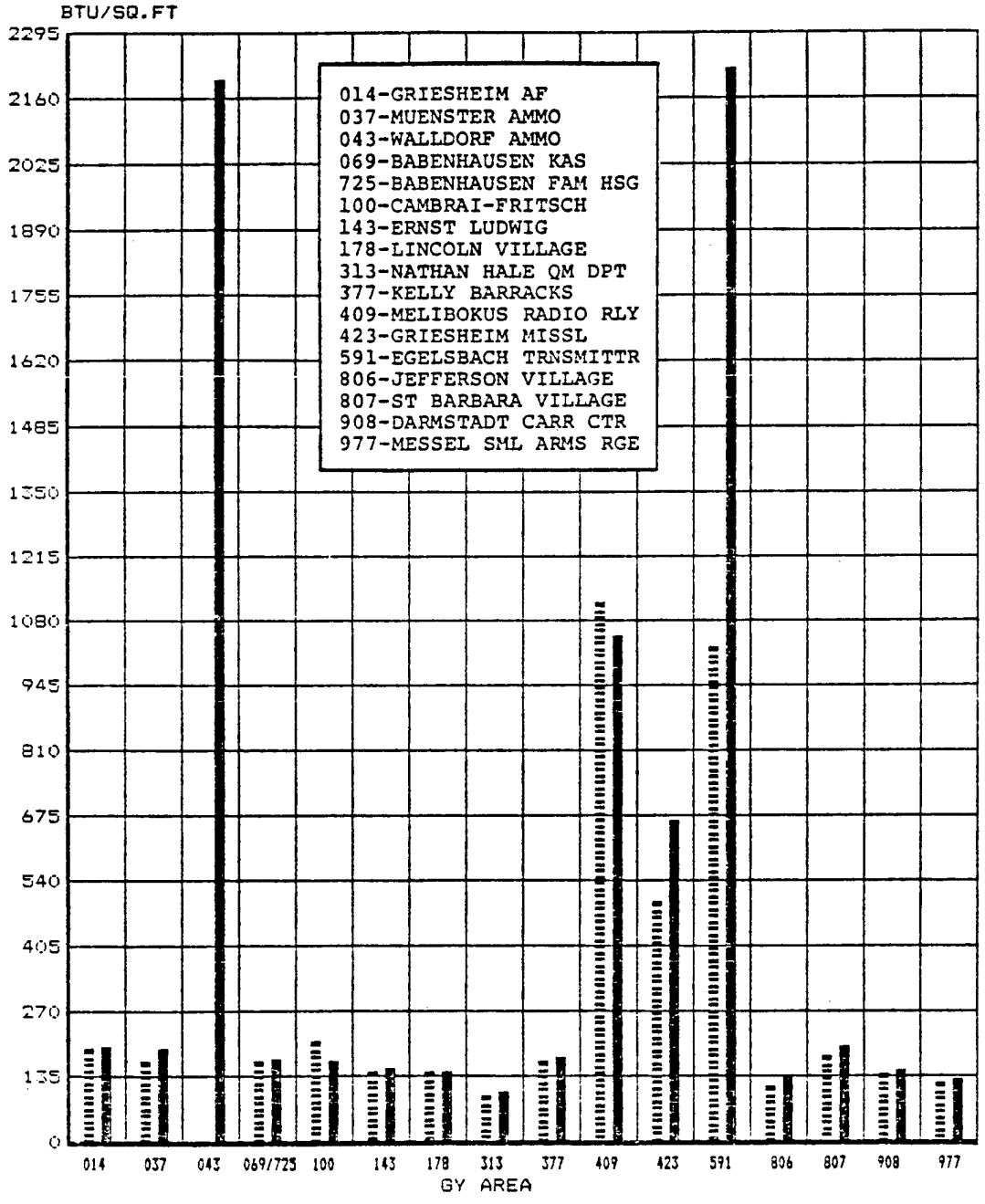


FIGURE A-3

COAL CONSUMPTION BY GY AREA
(FY 75 vs FY 82)

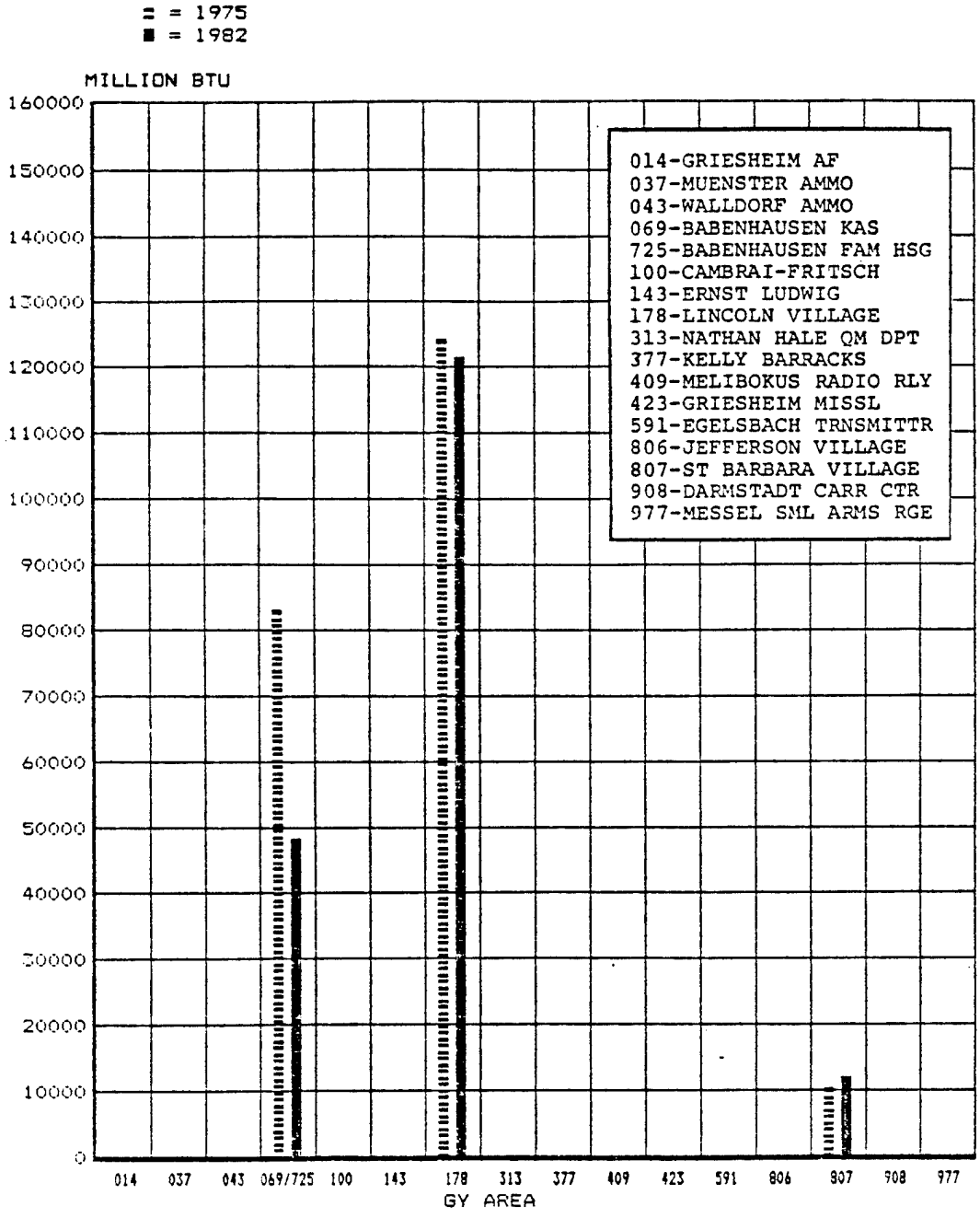


FIGURE A-4

FUEL OIL/GAS CONSUMPTION BY GY AREA
(FY 75 vs FY 82)

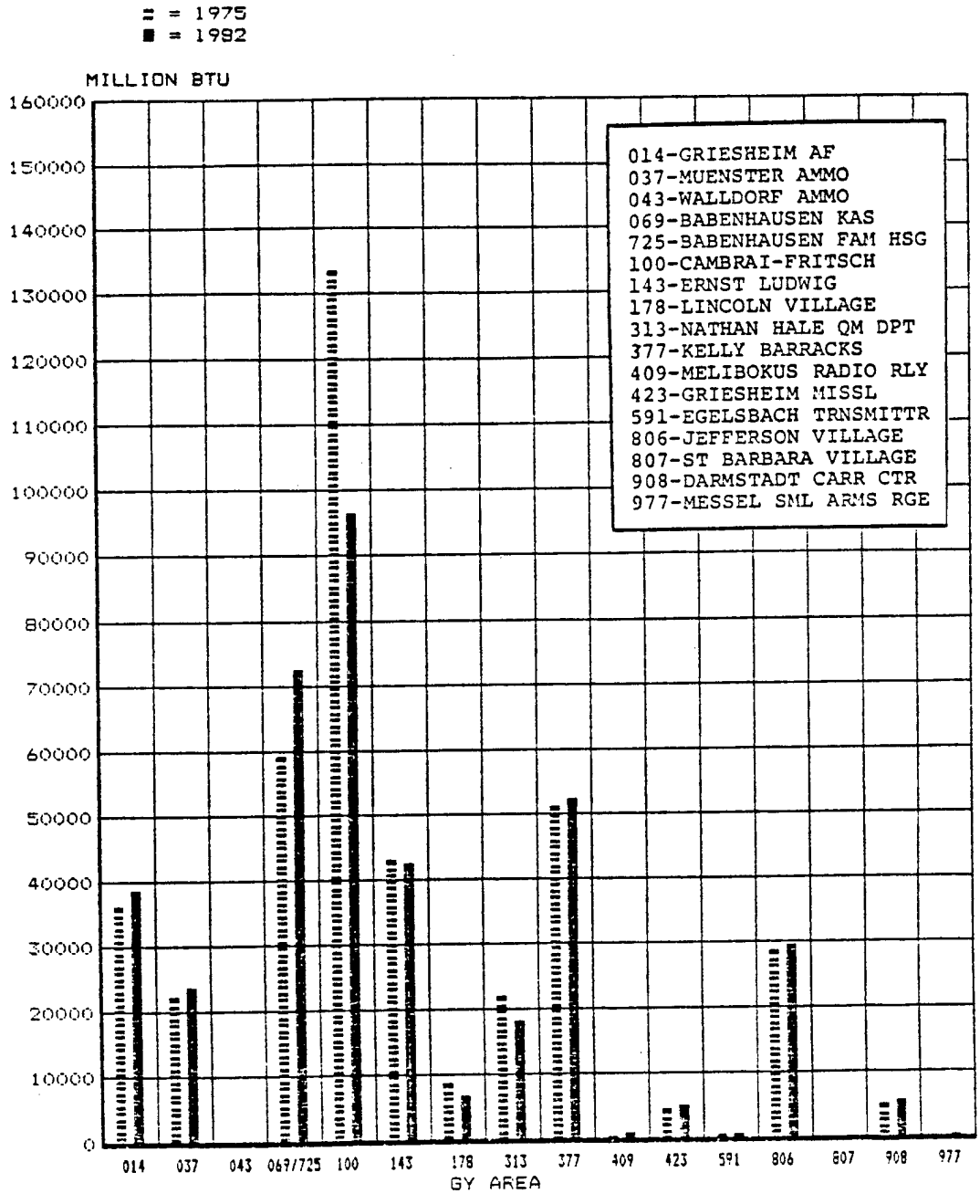


FIGURE A-5

ELECTRICITY CONSUMPTION BY GY AREA
(FY 75 vs FY 82)

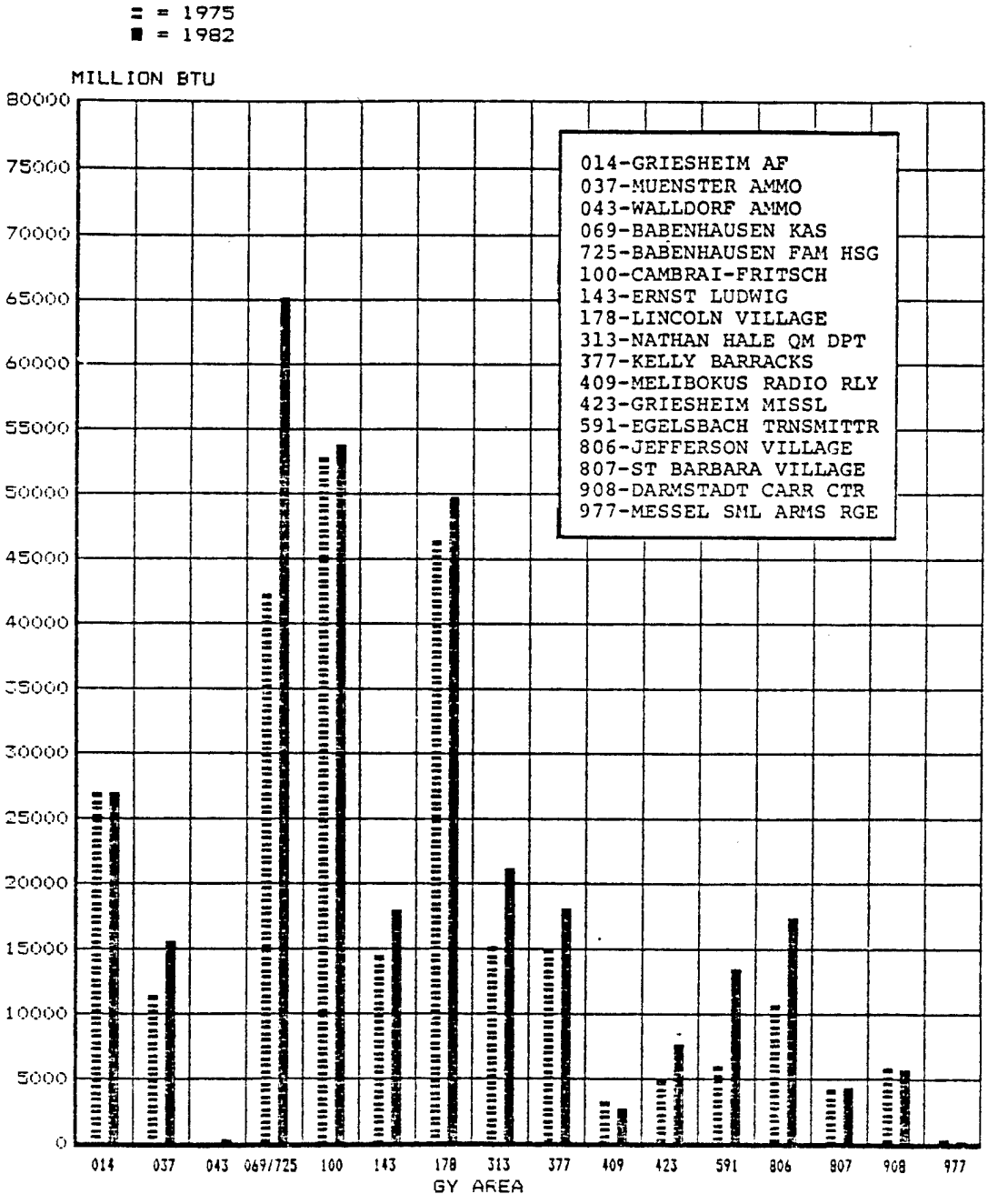


FIGURE A-6

CALCULATED ENERGY REQUIREMENT BY FACILITY TYPE
(Fossil Fuel and Electricity)

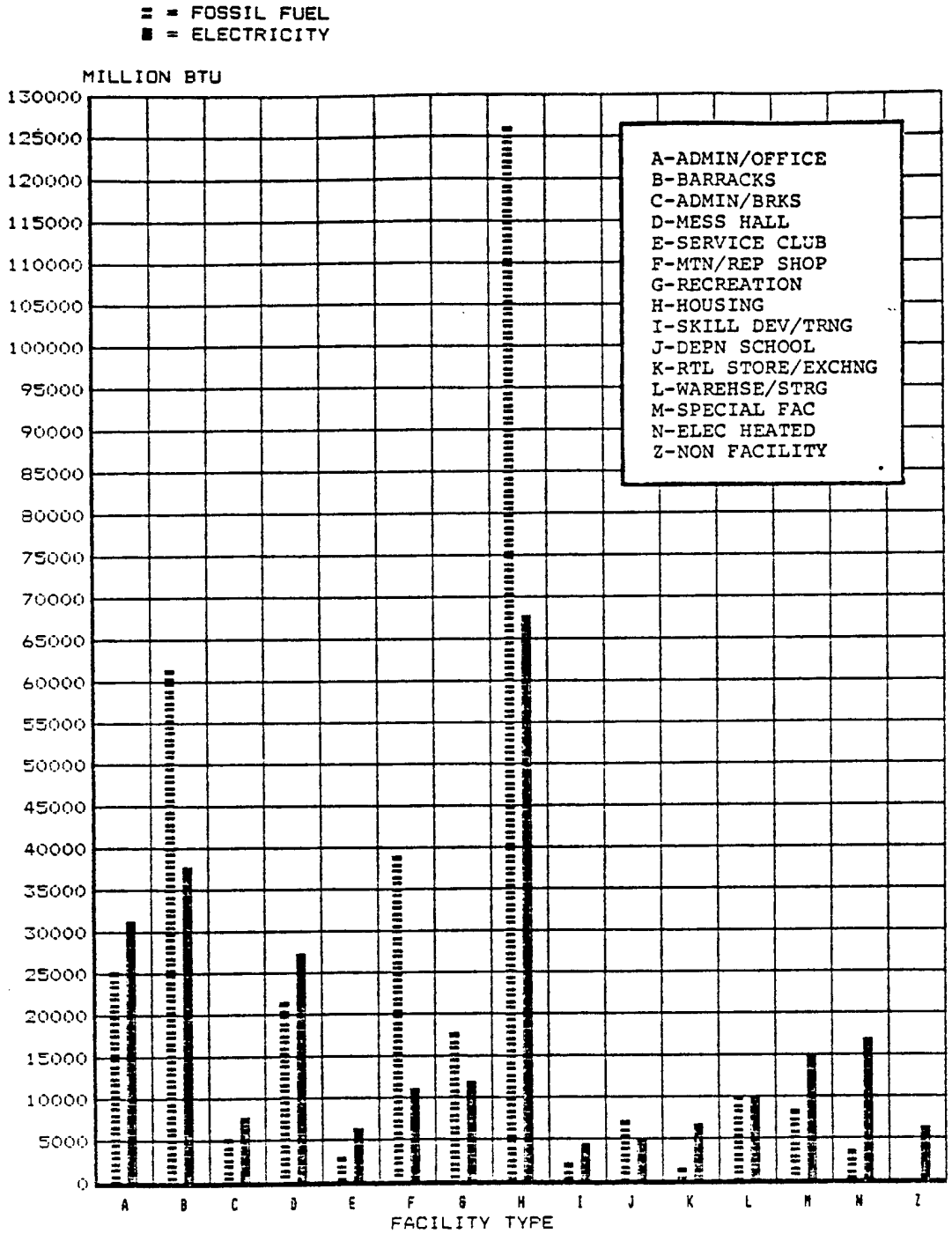


FIGURE A-7

CALCULATED ENERGY REQUIREMENT/SF BY FACILITY TYPE
(Total Energy)

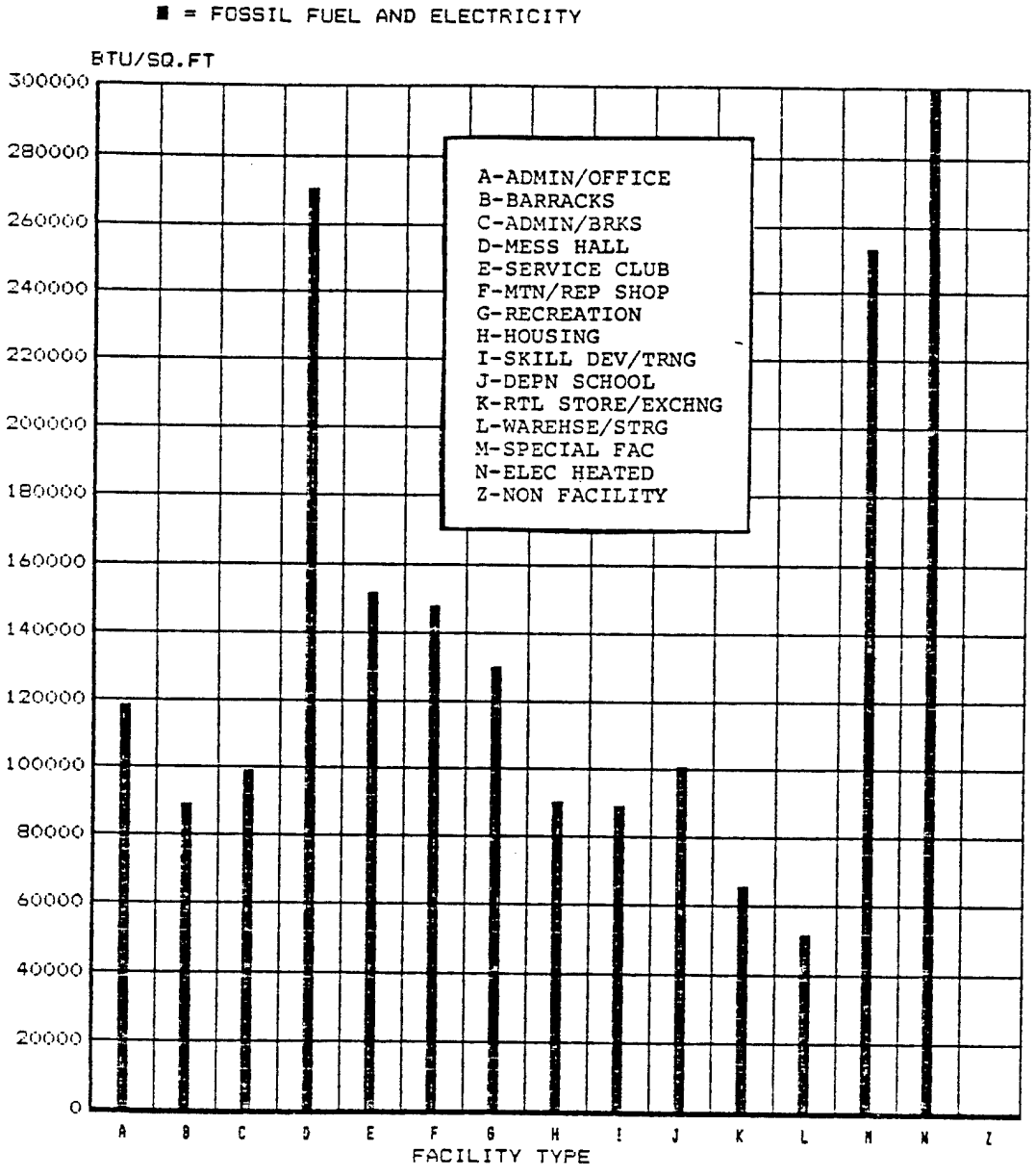


FIGURE A-8

CALCULATED ENERGY REQUIREMENT BY FACILITY TYPE
(Percent Area vs Percent Total Energy)

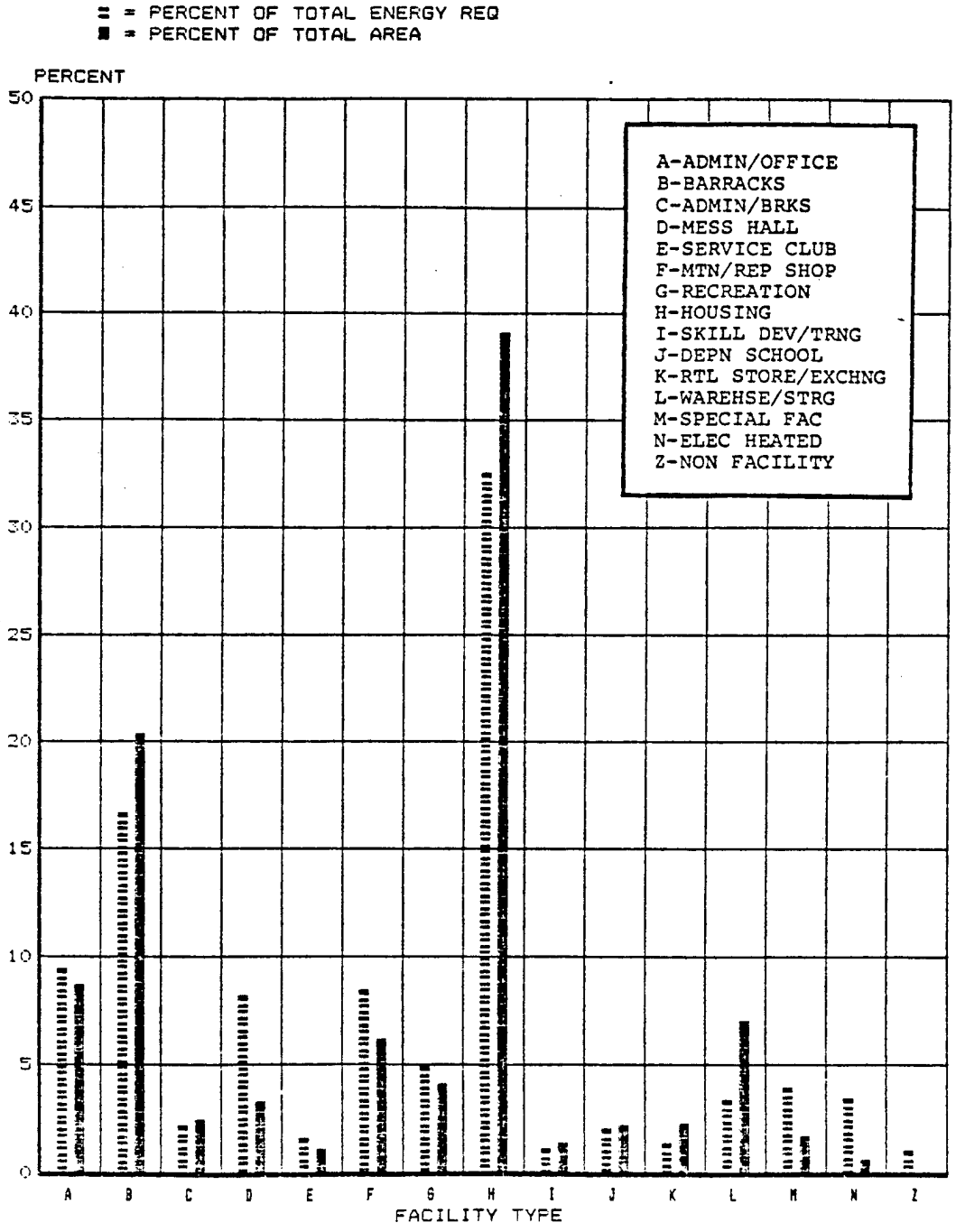


FIGURE A-9

ENERGY CONSUMPTION COMPARISON BY SOURCE
(FY 75 vs FY 85 W/ECOs)

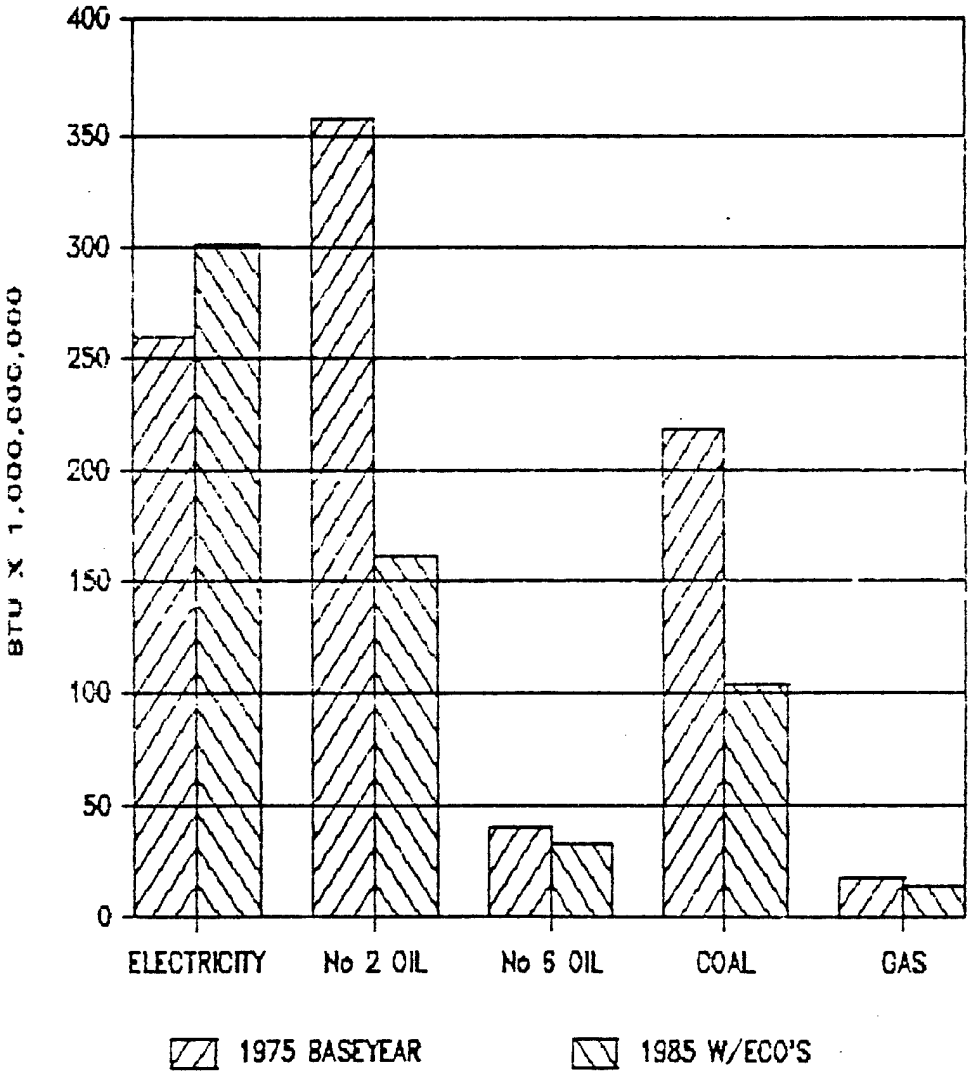


FIGURE A-10

ENERGY COST COMPARISON BY SOURCE
(FY 75 vs FY 85 W/ECOs)